must be a continuation of high pressure accompanying the movement of storms across the country to the north. Instances of both kinds occurred during the two seasons reviewed.

The logical conclusions of the study of two fire seasons are summarized as follows:

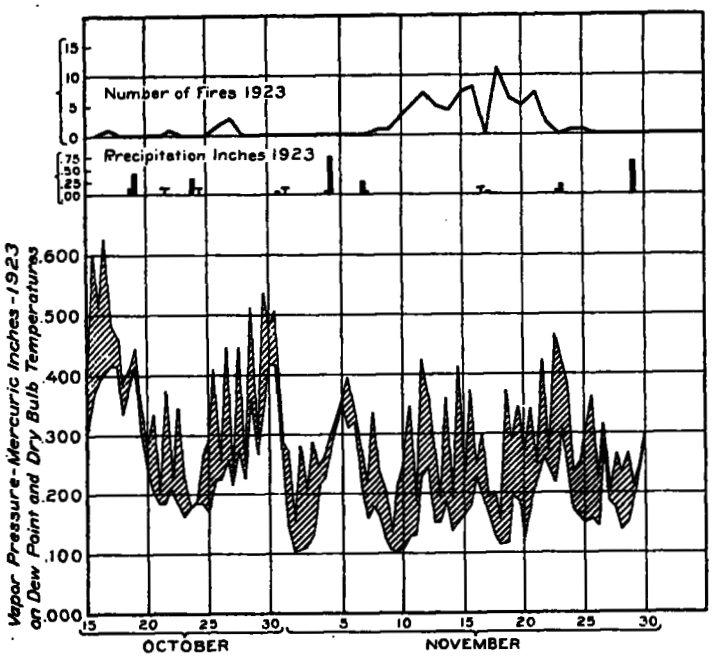

FIG.2-RELATION OF FIRES TO PRECIPITATION AND VAPOR PRESSURE.1923

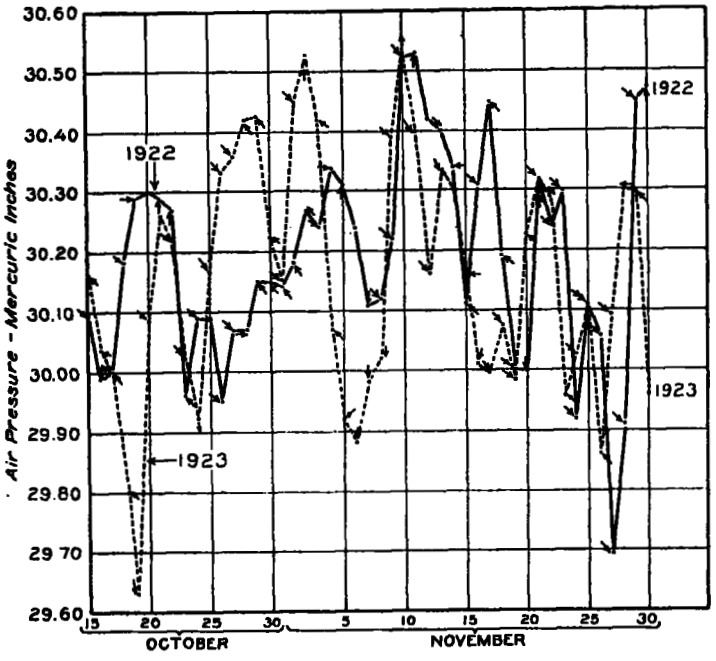

FIG.3-AIR PRESSURE IN 1922 AND 1923
(Arrows Indicate Wind direction)

1. Weather conditions are of minor importance until the leaf crop is down.

2. Heavy rains which pack the leaf litter retard its drying and make fire control easier.

3. Dry periods occur after the passing of storms and with the advent of high pressure. This induces winds from the interior of the continent, which are dry; it brings lower temperatures, clear days, and lower absolute humidity. Day temperatures are high in spite of heat lost by radiation at night. The large diurnal range of temperature makes relative humidity low at midday.

4. The Appalachian Plateau, by reason of its altitude and consequent radiation of heat, tends to induce a downward movement of air and retain high pressures.

5. Disturbances which displace the pressure conditions in times of severe fire hazard commonly advance over Montana or Texas and the Gulf. Storms of the latter type are less frequent in the late fire season.

6. The weather data collected daily by the Weather Bureau at Washington is broad enough to indicate such disturbances and the rate of movement with sufficient accuracy to forecast them at least three days in advance. This is not a marked departure from present Weather Bureau practice, since general weekly forecasts are now issued by this Bureau.

The undertaking of forecasts for the specific purpose of aiding in forest-fire control will further research in this line and result in a concerted effort to increase the usefulness of such a service. Studies of storm movement at times of great fire hazard as shown by fire records will furnish the experience needed to fix the paths of storms during the brief periods involved.

Field research should furnish a more accurate measure of successful prediction than chance fires by a study of the factors controlling leaf fall and the rate of drying of litter under varying conditions of the atmosphere.

634.9.43 : 551.594

LIGHTNING FIRE LOSSES[1]

By ROY N. COVERT, Meteorologist

As an introduction to the subject it is desired to state that while it is known that the Weather Bureau of necessity has carefully studied the thunderstorm and its phenomena both from the physical and climatic aspects, many do not realize that for more than 30 years this Bureau has been an earnest advocate of the protection of buildings and other property against lighting by suitable rodding. Amongst its literature will be found bulletins on protection appearing as early as 1894, and as an outgrowth, the Bureau is frequently called upon to advise inquirers concerning the proper methods and materials to be employed. Occasionally plans are drawn up in detail for the protection of Government structures, as for example the White House, which was rodded in 1910 after plans and specifications prepared by Professor Marvin.

The object of the study presented in this paper was to determine the relative liability of farm buildings to fire damage by lightning. This object has been reached only approximately and in part because of the nature and insufficiency of the available information, but there is enough of interest it is believed to merit consideration.

Following is a brief discussion of the data employed:

1. The annual lightning-fire losses by states for the years 1915 to 1922, both years inclusive, from which a yearly average was obtained, were furnished by the National Board of Fire Underwriters. These figures, given in dollars, represent all the losses reported by their Actuarial Bureau, and an additional 25 per cent estimated by them to cover unreported losses. Changes in value from year to year are taken into account in estimating losses.

2. The number of farms in each State reported in the 1920 census. A farm is defined as "all the land which is

[1] Presented before the American Meterological Society at its meeting in Washington, D. C., April 1924.

directly farmed by one person conducting agricultural operations." Tracts less than three acres are not farms unless products valued in excess of $250 were produced in 1919, or its operation required one person's continuous service.

3. The average value in dollars of the buildings per farm for each state as reported in the 1920 census. These figures are estimates of their value at the time of the census, and are not replacement values. They do not include buildings used for manufacturing purposes.

In an agricultural State such as Iowa the lightning-fire losses in the rural districts are found to be about 75 per

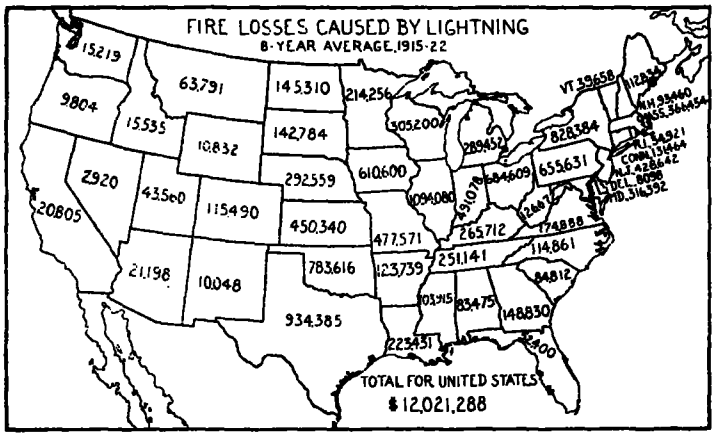

FIG. 1.—Average annual fire losses caused by lightning

cent of the total. This percentage would not be the same in a State like Massachusetts, but being unable to learn what it is, and for the sake of comparison, the farm building losses in each State were assumed to be the same part of the whole, i. e., 75 per cent of the total, or approximately 90 per cent of the reported losses, which, as before stated are increased by 25 per cent to cover unreported losses.

The estimated total farm building loss was next divided by the number of farms per State giving the loss per farm, and finally the ratio of the loss per farm to the average value of the farm buildings per farm in each State was computed. This number is an index, in the agricultural States at least, of the relative liability of the farm buildings to fire damage caused by lightning.

Taking Alabama as an example, the average annual reported loss was $66,780; nine-tenths of this, $60,102, is the estimated farm building loss; dividing by the number of farms, 256,099, the loss per farm was $.235, and the ratio of the loss per farm, $.235, to the average value of the farm building group, $499, is .00047; i. e., 47 is taken as the index number.

The average annual losses for the several States are shown in figure 1. The average annual loss for the whole United States is a little over 12 millions of dollars, which is probably a conservative figure. Illinois has the unenviable first place with an average annual loss of over a million dollars, undoubtedly due in large measure to the firing of farm buildings which are numerous and valuable, but also because of losses in the industrial sections. Texas is next in order because of its large area and the presence of highly inflammable oil-storage tanks. New York is third, its heavy losses being attributed to the same reasons given for Illinois. In general the highly developed agricultural States suffer heavy losses, as do likewise the thickly-populated industrial States of the northeast. The more destructive effect of the cyclonic thunderstorm is in evidence. For example, the combined losses in the States of Florida, Georgia, and Alabama, where the average annual number of thunderstorms, many of the so-called heat type, is nearly 75, amounts to $284,705, or less than the loss in Wisconsin alone, where the number of thunderstorms is about 30 per year. However, the number of farms and the average value of the farm building group must be considered. The buildings of an average Wisconsin farm are valued at $3,006, which is nearly equal to the combined values of the average farm building group in the three southern States. On the other hand there are nearly 620,000 farms in the latter as compared with about 189,000 in Wisconsin.

Referring to Figure 2, showing the index numbers which take into account the number of farms and the value of the farm building group, the three southeastern States are found to have index numbers greater than Wisconsin, that for Florida being nearly twice as great. The average of the numbers for the southeastern States is 55, as against 40 for Wisconsin, the average number of thunderstorms per year for each section being, respectively, 75 and 30. Comparing these figures, it is evident that a Wisconsin thunderstorm results in nearly twice as much damage as one in the South. Moreover, the rodding of farm buildings is known to be quite general in Wisconsin.

As before stated, it is believed that the index numbers for the agricultural States are fairly comparable and show the relative liability of farm buildings to damage. If the number is small as compared with States having equally destructive and frequent thunderstorms, then it is quite probable that protection against lightning is more general. Michigan, Wisconsin, Minnesota, and Iowa are States where it is estimated that somewhat more than half of the farm buildings are protected by rodding.

There are several anomalies which can be explained, as follows:

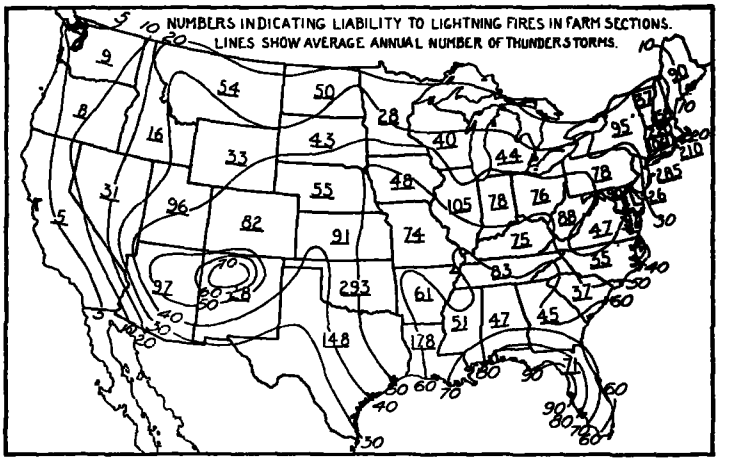

FIG. 2.—Index numbers indicating relative liability of farm buildings to fires by lightning

The large index numbers for Utah and Arizona are due to heavy losses occurring in one year only out of the eight for which data are available; a greater length of record would reduce the average per year.

Excessively large index numbers for Oklahoma, Texas, and Louisiana are due to the inclusion of the costly oil-tank fires in the total losses. It has not as yet been possible to separate these from the losses on other property.

In the industrial States of New York, New Hampshire, Massachusetts, Rhode Island, Connecticut, New Jersey, and probably Illinois, the index numbers are large because the rural losses are less than the assumed 75 per cent of

the total losses. Very destructive lightning fires occasionally occur, as, for example, the million-dollar elevator fire in Baltimore in 1922.

Before these index numbers can be fully interpreted, information should be available giving accurately the proportionate losses occurring in town and rural sections, and, probably more important, it is desired to know what percentage of the total number of farm buildings in each State is protected against lightning by rodding. Such information could be included in the next census.

TORNADO OF JUNE 22, 1923, AT FORT YATES, N. DAK.

By A. McG. BEEDE

On June 22, 1923, about 5 p. m., at Fort Yates, N. Dak., it was raining lightly and thundering, breeze southwest. My son called my attention to certain clouds about five miles away, up high, very black, and thrusting downward something shaped like a huge fan, wide end upward in the clouds. The clouds were slowly circling around and slowly moving northeastward (and so nearer to Fort Yates). This continued for 10 minutes, while the cloud mass had moved forward about three miles, and meanwhile the downthrust, always fan-shaped, had been made a dozen times and then taken up into the cloud. None of these downthrusts had reached the earth, though each one created wind disturbances under it on the earth.

Then a streaming, gray downthrust very rapidly extended nearly to the earth, about two miles southwesterly from Fort Yates, and there was great disturbance on the earth under it. In a moment it was lifted again, although the cloud mass had not lowered at all between clouds and sunshine. This was repeated three times while the cloud mass was rather slowly circling around and moving northeasterly. These three downthrusts were one minute apart.

Just then a streamer extended quickly to earth, about 1½ miles from Fort Yates. It was a slender streamer, light gray in color. As it touched the earth there arose around it a funnel-shaped vortex, very small on the earth and enlarging at an angle of about 15 degrees, whirling around more slowly than some others I have seen; the funnel arose about 200 feet above the earth, while in its center and extending upward to the high clouds, the streamer could be seen, the cloud still circling around and moving northeasterly toward the cloud over the Missouri River. Then this slight streamer was taken up into the cloud with the vortex following it, and disappeared. All this had been done in about one-fourth of a minute.

The vortex pulled up bushes and grass and some dirt, and spewed this material over an area many times wider than the vortex. The next downthrust, half a minute later, was larger and as rapid, reaching the earth about 300 yards onward from the last thrust mentioned. Its behavior, funnel and all, was like its predecessor, only more forceful. Then came a third thrust to earth, in a large bunch of bullberry trees, some of them 4 inches in diameter and deeply rooted, and it pulled them all up by the roots like weeds, drawing them up in the funnel, whence they were spewed out. This funnel was 300 to 500 feet high, but still the angle of the sides was about 15 degrees. There were nine more downthrusts to the earth in rapid succession, while the upper cloud did not lower at all, but kept on a level with the great cloud it was approaching.

Finally, the tornadic cloud reached the great cloud, which was moving up river all the time very slowly, and just as this happened, a last streamer was thrust halfway down to the earth, just westerly from the Congregational mission, and under it barrels and unsawed poles and all movables went whirling around and abroad in every direction. It was thundering near and heavy all of the time, but I saw no lightning, and there was not much rain, but a few scattering drops only, and the surface of the earth was rather dry, though just below the surface it was saturated with water. As the two clouds merged the combined cloud mass quickening its slow movement, moved up river, away from the river north by a little westerly over the old town of Fort Yates, and over St. Peter's church. At about this time there was another tornado over west in Grant County.

As the next to last full streamer went down numerous crows appeared in the vortex and were whirled around, but I did not see any of them fall, nor were dead crows there later. I did not see the crows fly *into* the vortex, but saw them about 100 flying and twirling *in* it. Perhaps they were taken up from where they had taken refuge, in a bunch of bushes.

There was no damage, because nothing was in the tornado's path to be damaged.

Old Indians claimed that whenever there is a whirlwind on the earth tossing leaves and grass and dust, there is a ghost-like streamer from on high which the eyes of some persons can see. They called this streamer "Amakpiya—ta nagi clouds—ghost)."

EDITOR'S NOTE.—The rather faintly developed tornado described by Mr. Beede occurred in the southern quadrant of a cyclonic system centered at 8 a. m. 75th meridian time over Manitoba; its entire southern half was a region of thunderstorms and squall winds. Mr. Beede describes what apparently was a tornado of slight intensity that developed in the general storm area.

TORNADO AT NORTHFIELD, MINN., MAY 3, 1922

By U. G. PURSSELL, Meteorologist

[Weather Bureau Office, Minneapolis, Minn.]

A small tornado of little violence apparently developed a short distance west of Northfield about 7 p. m. May 3, pursued a path approximately in a northeast direction, about 4 miles in length, and disappeared soon after crossing the hill upon which St. Olaf College of Northfield stands. The damage was confined to the wrecking of small farm buildings, barns, and garages.

The funnel cloud was seen by a number of people in Northfield and was photographed by several persons. We are indebted to Mr. Martin N. Ayre and Mr. Paul J. Orebo respectively, for the two prints reproduced in Figures 1 and 2 below. Unfortunately the details of the two views are not known, the first named (Fig. 1) was evidently made from a point nearer to the funnel cloud than the second. Both photographs must have been made about 7 p. m. The photograph by Mr. Ayre was taken at one-quarter to one-third mile; Mr. Orebo's was more distant.